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## ENGINEERING AND EQUIPMENT

No. 87

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26 July 1982

# USSR REPORT

## ENGINEERING AND EQUIPMENT

No. 87

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UDC 621.125-55.001.24

# SPECIAL FEATURES OF CALCULATING DYNAMICS OF MARINE STEAM TURBINE REGULATORS

Leningrad SUDOSTROYENIYE in Russian No 3, Mar 82 pp 28-30

GORDEYEV, V. A., GOL'DBERG, M. E. and IGNAT'YEVA, B. P.

[Abstract] Regulation of propeller speed and steam pressure on board a ship with steam turbine plant is considered by means of a system consisting of 25 electric and fluidic components (controller, signal amplifiers and converters, adders, stiff feedback loops, main and high-speed intermediate servomotors, regulating valves and pressure gauge). The propeller speed is regulated according to a proportional law, the pressure of live steam in the main duct is regulated preferably according to a proportional plus integral law. Such a system is most expediently designed by the method of logarithmic amplitude-phase-frequency characteristics, for which a digital computer is most convenient, with harmonic balance and transient analysis using an analog computer as well. The major sources of nonlinearities in the system are the torque-speed characteristic and the insensitivity zone of servomotors, and hysteresis of electrofluidc converters. An important factor in design calculations, aiming at a zero static error, is the dependence of regulation dynamics on turbine and regulator parameters. The length of the transient period, specifically, depends on the time constant of the turbine and the travel time of the intermediate servomotors. A minimum-pressure regulator for this system has been designed on this basis. Figures 3, references 5 Russian.
[205-2415]

UDC 629.12.011.562.1.001.24:539.433

VIBRATION RESISTANCE OF HULL STRUCTURES IN ENGINE COMPARTMENTS

Leningrad SUDOSTROYENIYE in Russian No 3, Mar 82 pp 22-23

NIKOL'SKIY, Yu. A. and SHCHUKINA, Ye. N.

[Abstract] After approximately 20 years of experience in running steamships of Soviet fleets with low-speed high-power diesel engines, there still remain unresolved differences of opinion regarding the vibration resistance of hull structures in engine compartments and the methods of improving it. These authors disagree with S. A. Khudyakov ("Vibration-Proofing of Engine Room Structures on Steamships", SUDOSTROYENIYE No #, Mar 82 pp 20-22) on five points: 1) The given ships of the far-eastern fleet were built abroad and, therefore, design recommendations based on their performance must be regarded with caution. 2) The conclusions about inadequate stiffness of structures and this being the cause of high vibration levels at resonance are erroneous. The stiffness is adequate and resonance is to be avoided by departing from it. 3) The requirement that the lowest natural vibration frequencies of the structural components be higher than the fundamental frequency of unbalance forces and moments (engine speed x number of cylinders) is disputable. This requirement can rarely be met in practice and is often unnecessary, inasmuch as the intensity of vibration forces also depends on the location and distance from the source. There are, furthermore, other more practical recommendations available. 4) On the frequency diagram proposed by S. A. Khudyakov the range of allowable natural frequencies must not be confined to 3% of the spectrum but widened so as to allow for calculation error and safety margin. 5) The criteria of force and moment unbalance based on mass and torque alone are not sufficiently objective and complete, at least engine power and number of cylinders must also be included. On the whole, the approach taken by S. A. Khudyakov to vibration-proofing of structural components has merits. His treatment of vibration-proofing of mechanisms and power components is still inadequate. More research and better recommendations are needed in this area.
[205-2415]

UDC 629.12.011.562.1.001.11:539.433

VIBRATION-PROOFING OF STEAMSHIP ENGINE ROOM STRUCTURES

Leningrad SUDOSTROYENIYE in Russian No 3, Mar 82 pp 20-22

KHUDYAKOV, S. A.

[Abstract] Use of low-speed high-power diesel engines on ships creates a serious vibration problem. An engineering solution of this problem requires selection of the appropriate physical model and of an algorithm for determining the free vibration frequencies, an analysis of unbalance forces and moments,

calculation of forced vibration modes and identification of resonators in the diesel-hull system. The results of analysis and calculations made for several steamships ("Mikhail Kalinin", "Belomoskles", "Nadym", "Varnemyunde"), supported by experimental data, indicate that the proper approach to prevention of high vibration levels is through normalization of free vibration frequencies of the hull estructures and of mechanisms that cause frequency excursions, with the aid of universal charts and diagrams applicable to any low-speed diesel engine as a vibration spectrum source. Figures 2, tables 2, references 9: 5 Russian, 4 Western.
[205-2415]

UDC 629.124.77.039

'PLAMYA' HOVERCRAFT

Leningrad SUDOSTROYENIYE in Russian No 3, Mar 82 pp 3-4

ZOROASTROV, V. K. and SHIKIN, V. K.

[Abstract] The latest in the series of river boats built with air cushion and skegs is the "Plamya" for rapid transport of forest fire fighting equipment. This 34.5 ton vessel is 26.1 m long and 6.5 m wide, with maximum height 5.5 m at midspan. It runs on two 380 kW - 1500 rpm diesel engines (ZKD12N-520) and has a range of 400 km without refueling. The air cushion is produced by a special high-pressure chamber under the bottom, between skegs along the boards and flexible baffles under stern and bow. The vessel is divided into a cargo deck with a 7.3 metric ton load capacity and facilities for a crew of 18, a rudder house with facilities for a crew of 2, a service room for auxiliary facilities and an engine compartment. Electrical power for internal needs is provided by generators and storage batteries, with means for hookup to a power line on shore. The hull is made welded light-weight AMg-61 and D16 aluminum alloy. The vessel has been thoroughly tested since 1980 and found fit for service. It should be particularly useful as alternative or even sole means of transportation to regions endangered by fires. Figure 1, tables 1.
[205-2415]

UDC 621.5:621.165:621.311.25

# OPTIMIZATION OF PULL-UP OF POWER UNITS WITH WATER-MODERATED WATER-COOLED REACTORS

Moscow TEPLOENERGETIKA in Russian No 1, Jan 82 pp 30-33

GOLOVACH, Ye. A., candidate of technical sciences, KIM, V. Ye., engineer, and FREYBERG, V. G., engineer, Scientific-Industrial Association Central Institute of Boilers and Turbines

[Abstract] The pull-up performance of power units in AES's with VVER-1000 reactors is analyzed on the basis of a mathematical model consisting of a system of linearized differential equations $\dot{X} = Ax^T + Gu^T$ ($x^T = \{x_1, x_2, \ldots, x_n\}$ is vector of variables, A is nXn-dimensional system matrix, $u^T = \{u_1, u_2, \ldots, u_m\}$ is vector of control actions, G is nXm-dimensional control matrix). A standard system of power regulation through the turbine is included and the optimum power control during the transient pull-up period is sought through minimization of the quadratic quality-criterion functional

$$I = \int_0^\infty (x^T Q x + u^T B u)\,dt$$

(Q is positive-semidefinite nXn-dimensional weighting matrix, B is positive-definite mXm-dimensional matrix). The minimum of this functional is determined by the maximum dynamic overshoot opening of regulators and depends on the values of the coefficients in both matrices. The minimum of this functional in turn yields the optimum control $u = -B^{-1}G^T PX$, where P is a symmetric positive-definite matrix that satisfies the Riccati equation $PA + A^T P - PGB^{-1}G^T P + Q = 0$. The coefficients in matrices B and Q as well as control actions $u_1$ and $u_2$ for this kind of power plant have been evaluated numerically. Figures 2, table 1, references 21: 7 Russian, 4 Western.
[182-2415]

UDC 621.039.5/.6

STUDY OF AND OPERATING EXPERIENCE WITH STEAM GENERATORS IN SODIUM-WATER AES WITH BN-350 FAST BREEDER REACTOR

Moscow TEPLOENERGETIKA in Russian No 1, Jan 82 pp 7-13

KIRILLOV, P. L., doctor of technical sciences, KISELEV, G. V., candidate of technical sciences, POPLAVSKIY, V. M., candidate of technical sciences, SAMARKIN, A. A., engineer, and TITOV, V. F., engineer

[Abstract] An experiment-commercial BN-350 FBR has been operating since 1973 in a unique atomic electric power and distillation plant in Shevchenko on the Mangyshlak peninsula. The 3-stage configuration is classical, with 1100 $m^3$ of sodium available for cooling and steam generated at rates up to 1400 t/h by heat coming from the reactor core through six identical loops (one standby). Each steam generator consists of a vertical evaporator with natural circulation through Field tubes and a U-shaped sodium-water heat exchanger. The evaporator has been designed to minimize temperature drops in the tube plates, to ensure stable natural circulation of steam-water mixture over a wide range of power levels, to eliminate the need for compensating thermal expansion, and to facilitate operation at various pressures. These steam generators were tested for reliable and safe operation, their stability limits were established at pressures from 2.5 to 5.2 MPa, the sodium loop and the water loop were checked for leaks, the sensitivity of the protective leak control system was measured and found to be adequate. The first run extended from 1973 to 1975. During overhaul the tubing, made of 1Kh2M steel, was inspected ultrasonically as well as by means of x-ray diffraction and optical flaw detection. The second failure-free run lasted from 1976 through 1980. Figures 8, tables 3, references 11: 5 Russian, 7 Western.
[182-2415]

UDC 621.039.515

NEUTRON DISTRIBUTION IN REACTOR CORE WITH TVS-2M FUEL ASSEMBLIES

Riga IZVESTIYA AKADEMII NAUK LATVIYSKOY SSR; SERIYA FIZICHESKIKH I TEKHNICHESKIKH NAUK in Russian No 1, Jan-Feb 82 (manuscript received 24 Aug 81) pp 6-9

DEMIN, V. P., KRUZE, U. A., PLATATSIS, E. Ya., RUPENKHEYT, Ya. B., SOBOLEV, Yu. A. and TOMSONS, E. Ya., Institute of Physics, LaSSR Academy of Sciences

[Abstract] The neutron distribution in a reactor core formed by a heterogeneous array of uranium-aluminum TVS-2M fuel assemblies, 3x3 without the center tube, with a 13.6-20.4 cm thick lateral neutron reflector made of

metallic beryllium was measured in the RKS test stand at the Institute of Physics under critical conditions (1.35 kg $U^{235}$ charge, ratio of hydrogen to $U^{235}$ nuclei equal to 400, effective neutron multiplication factor 1.012±0.001). Corresponding calculations were made by the Monte Carlo method (MMK-10 program). The energy spectrum of neutrons at the core center was determined over the $10^{-6}$-$10^{1}$ MeV ragne. The neutron flux density distributions along the core radius and across the core height were determined for 0.0253 eV neutrons. The distributions of uranium fission density across the core diameter and across the core height were also calculated, and measured with the aid of a miniature pulse-type fission chamber. The results yield rather complete data on the nonuniformity of the neutron distribution and on peak neutron concentrations within the volume of such a reactor core in IRT and VVR research reactors using 90% $U^{235}$ enriched fuel. Figures 7, references 5 Russian.
[187-2415]

UDC 621.039.51

CRITICAL PARAMETERS OF REACTORS WITH TVS-2M FUEL ASSEMBLIES AND VARIOUS NEUTRON REFLECTORS

Riga IZVESTIYA AKADEMII NAUK LATVIYSKOY SSR: SERIYA FIZICHESKIKH I TEKHNICHESKIKH NAUK in Russian No 1, Jan-Feb 82 (manuscript received 24 Aug 81) pp 3-5

KRUZE, U. A., PLATATSIS, E. Ya., TOMSONS, E. Ya., DEMIN, V. P. and SOBOLEV, Yu. A., Institute of Physics, LaSSR Academy of Sciences

[Abstract] The critical parameters of IRT and VVR reactors with TVS-2M fuel assemblies were evaluated experimentally in the RKS test stand at the Institute of Physics and theoretically by calculations according to the Monte Carlo method (MMK-10 program). Data on number of fuel assemblies, mass of $U^{235}$, volume of reactor core, concentration of $U^{235}$ nuclei in reactor core, ratio of hydrogen to $U^{235}$ nuclei, thickness of neutron reflector and effective neutron multiplication factor have been obtained for three different neutron reflectors: water, graphite, beryllium. The results indicate that replacement of water (100 cm thick) with graphite (20-47 cm thick) or beryllium (6.7-20 cm thick) reduces the uranium charge necessary for reaching the critical state by 36% and 52% respectively, also reducing the reactor dimensions and weight. Figure 1, table 1, references 4 Russian.
[187-2415]

UDC 621.039.514

IMPROVED SENSITIVITY OF TEMPERATURE MEASUREMENT AT FUEL ASSEMBLIES IN SODIUM-COOLED FAST REACTOR

Moscow ATOMNAYA ENERGIYA in Russian Vol 52, No 3, Mar 82
(manuscript received 2 Feb 81) pp 164-168

ADAMOVSKIY, L. A., YEFIMOV, V. N., KEBADZE, B. V. and MARKIN, S. A.

[Abstract] For correct and reliable detection of anomalies in reactor fuel assemblies it is expedient to monitor not only temperature deviations but also changes in the level of temperature fluctuations. A study was made with chromel-alumel thermocouples installed 20 mm behind the outlet from fuel assemblies in the BOR-60 reactor to establish a relation between temperature deviation during anomalous operation and temperature fluctuations during normal operation. Measurements of background noise and evaluation of data on the basis of the Wiener-Hopf equation for auto- and cross-correlation functions indicate that fluctuations of the coolant flow rate are the most likely source of temperature fluctuations, while incomplete temperature equalization during mixing of sodium streams coming from individual fuel cells is an insignificant factor. It is still necessary to determine the contribution of noise due to fluctuations of the neutron flux, which can be done only indirectly. On the basis of results already available, it appears feasible to improve the sensitivity of temperature measurement by devising an appropriate compensation system which will also suppress the effect of non-correlated noise. The dispersion of temperature fluctuations is best estimated on the basis of chi-square distribution for a certain frequency range, the temperature deviation assumed to have normal distribution. Inclusion of adaptive control will take care of permissible normal changes in the dynamic relations between parameters and in the characteristics of noise sources occurring in the course of reactor operation. Figures 5, references 9: 6 Russian, 3 Western.
[209-2415]

UDC 621.039.6

DYNAMIC STABILITY OF LIQUID FIRST WALL IN PULSED FUSION REACTORS

Moscow ATOMNAYA ENERGIYA in Russian Vol 52, No 3, Mar 82
(manuscript received 18 Mar 81, after final revision 29 Jul 81)
pp 176-180

KRAVCHUK, S. P. and NOVIKOV, V. M.

[Abstract] The first wall in some pulsed fusion reactors with triggering by laser or relativistic electron beams is a layer of molten salts (metal fluorides), that contains gas and vapor bubbles as cavitation nuclei. The dynamic behavior of such a wall after pulse heating by a neutron stream is

described here in the approximation of one-dimensional displacement of a plane wall segment. The velocity of neutrons is much higher than the velocity of sound in the wall material and, therefore, it is permissible to assume that they are absorbed "instantaneously" with a resulting temperature rise. Assuming exponential space distribution of the initial temperature jump and an instantaneous pressure jump with appropriate boundary conditions, the corresponding equations of hydrodynamics for gas-liquid mixtures are put in Lagrangian coordinates, linearized, and supplemented with an equation describing vibrations of a bubble. An exact solution to this system can be obtained analytically in the form of Fourier series. Quantitative estimates are possible, however, on the basis of simplifications valid for the short time intervals involved. For reference, estimates for water are compared with data based on van der Waals, Bridgman and Zel'dovich equations of state. An estimate of the wall strength on the basis of a quadratic pressure-veloctiy relation reveals that molten salt is "stronger" here than steel and that, in the presence of enough bubbles, the amplitude of the pressure dumping wave becomes small. Bubbles do not merge, their radii hardly changing during vibrations, and thus do not split the wall. The authors thank L. M. Satarov for many discussions and S. A. Kopakov for assistance in calculations involving neutron physics. Figures 2, references 12: 9 Russian, 3 Western. [209-2415]

UDC 621.039.51.14

## ESTIMATING RESIDUAL CAPACITY OF URANIUM-GRAPHITE CHANNEL REACTORS

Moscow ATOMNAYA ENERGIYA in Russian Vol 52, No 3, Mar 82
(manuscript received 9 Mar 81) pp 158-164

YEMEL'YANOV, I. Ya., KLEMIN, A. I., TARATUNIN, V. V., YEMEL'YANOV, V. S. and MOROZOV, V. B.

[Abstract] Predicting the residual capacity of reactors is a particularly timely problem in the case of old uranium-graphite channel reactors (operating already 27 years in the Obninsk AES, 23 years in the Siberian AES, 17 and 14 years in the Beloyarsk AES). The problem reduces to estimating the degree of technical degradation due to aging. A mathematical model of the aging process is constructed here that includes differential aging indicators (irreversible changes in individual reactor components) along with integral aging indicators (mean annual shutdown time) and uses three criteria of reactor disability. Criterion A is met when a failure occurs after which further operation becomes impossible. Criterion B is met when integral aging indicators reach maximum permissible levels without ultimate failure (criterion A) occurring. Criterion C is met when differential aging indicators reach maximum permissible levels without ultimate failure (criterion A) occurring. On this basis and with the theory of Markov processes applied to chains of reactor events, the reactor operation is represented by a state diagram and the latter is translated to a system of Kolmogorov-Chapman differential equations with an appropriately modified

number of integral aging indicators. The calculation of integral aging indicators is illustrated on a water-graphite channel reactor. Figures 5, references 6 Russian.
[209-2415]

UDC 621.039.534.25:539.434

FATIGUE STRENGTH OF JOINTS BETWEEN TUBES AND TUBE RACKS IN HEAT EXCHANGERS IN AES'S

Moscow ENERGOMASHINOSTROYENIYE in Russian No 2, Feb 82 pp 29-30

ZAYTSEV, G. Z., candidate of technical sciences, CHUDNOVSKIY, A. D., candidate of technical sciences, and SAN'KOV, N. I., engineer

[Abstract] A method has been developed for comparative evaluation of the fatigue strength of tube-rack joints in heat exchangers in AES's. Such joints are made either by wireless argon-arc welding with a tungsten electrode and VS-2 activating flux or by electron-beam welding. The depth of the molten layer is 4-6 mm and 5-8 mm respectively. Tube specimens with a 2.5 mm wall thickness were rolled down from a 16 mm to a 15 mm in diameter, rack specimens were prepared in the form of sleeves with mounting threads. The material of all specimens was Kh18N9 steel. Welds were tested in a TsDM-20-PU-10 vibrator under an asymmetric tensile load at a frequency of 2000 cycles/min with a constant stress per cycle. Subsequent metallographic examination and hardness testing of seams and heat-affected zones after fracture revealed poorer quality and lower fatigue strength of joints produced by argon-arc welding. Figures 2, references 5 Russian.
[207-2415]

UDC 620.179.16

MEASUREMENT OF PARAMETERS OF ACOUSTIC EMISSION DURING HYDRAULIC LOADING OF VVER-1000 REACTOR SHELL IN NOVOVORONEZH AES

Moscow ENERGOMASHINOSTROYENIYE in Russian No 3, Mar 82 pp 33-36

TRIPALIN, A. S., candidate of physico-mathematical sciences, KUZ'MIN, G. A., engineer, YELETSKIY, S. A., engineer, KOLOMIYETS, Yu. V., engineer, and SHIKHMAN, V. M., engineer

[Abstract] The shell of the VVER-1000 water-moderated water-cooled reactor in the fifth power unit of the Novovoronezh AES was inspected by the method of acoustic emission during adjustment and startup periods. Amplitude and intensity of acoustic emission signals were recorded through two wideband channels, through one wideband channel with four amplification channels for determining the coordinates of flaws, and for calibration against a

reference oscillator. The equipment includes an AP-33E device with three identical wideband conversion-amplification-filtration-measurement channels, an N-327/5 five-channel automatic instrument for analog recording on paper tape, a UKD-44E device for measuring the time difference between signal arrivals, and a ShCh-68000K high-speed printer. The transducers in the AP-33E device are disks of PKR-1 piezoceramic material, 10 mm in diameter and 2 mm thick, polarized across the thickness and very weakly damped. Their sensitivity peaks match resonance in various vibration modes so that each cell can be used universally over the entire operating range. An analysis of acoustic emission data obtained during three loading cycles reveal a correlation between acoustic emission and loading pressure, with the emission intensity peaking at certain pressure levels, and dependence of the emission intensity on the loading rate. The data also reveal a partial Kaiser effect, namely some lowering of the intensity peaks in successive loading cycles. The amplitude distribution of acoustic emission signals provides information about defectiveness of the shell. The ultrasonic flaw detector has revealed a few fine cracks which would pass standard inspection. Figures 6, references 4 Russian.
[208-2415]

UDC [621.311.25:621.039].3.07

CYCLING CAPABILITIES OF NUCLEAR ELECTRIC PLANTS WITH VVER-440 REACTORS

Moscow ELEKTRICHESKIYE STANTSII in Russian No 3, Mar 82 pp 6-10

LAUKIA, A., PORKKHOLM, K., engineers, KOPYLOV, I. B., (deceased), candidate of technical sciences, and SHCHUROV, V. M., engineer, Imatran Vojma Company, Finland; All-Union Scientific Research Institute of Electric Power Engineering

[Abstract] Technical data are given on the Loviisa nuclear electric plant, a joint project of Finland and the Soviet Union. The facility contains two 440 MW power units based on Soviet VVER-440 reactors. Each unit consists of a nuclear steam-raising system with thermal power of 1375 MW, two K-220-44-2 turbine installations rated at 235 MW, and two TVV-220-2A generators with continuous-duty power of 235 MW. Thanks to international cooperation, the plant is equipped with the latest automation and safety devices. The first phase of the facility went into operation in May 1977, and the second phase was put on line in January 1981. Test results have shown that the nuclear facility has high flexibility as a base-load unit, and can operate with considerable fluctuations of power requirements. With respect to short-term cycling capabilities, the plant can handle step changes of $\pm$5% in output power with adjustment time of less than 30 s, and step changes of $\pm$20% with adjustment time of about 6 minutes. Regulation on a dialy basis covers a power range of 80-100% of rated capacity with gradient of from 0.4 to 4% per minute at a dynamic error of no more than 2%. The automatic power control system of the facility maintains preset power within 0.5% of the station rating. Figures 6.
[201-6610]

UDC 621.311.25:621.039.001.24

ACCOUNTING FOR PRIMARY REACTOR FUEL CHARGE AND PLANNING FUEL COMPONENT OF NUCLEAR ELECTRIC PLANT

Moscow ELEKTRICHESKIYE STANTSII in Russian No 3, Mar 82 pp 10-12

GUSEV, V. N., candidate of technical sciences, and TITOV, V. V., engineer, Leningrad Polytechnical Institute

[Abstract] The article is a response to L. D. Gitel'man's article "Particulars of Accounting and Planning for Expenditures on Nuclear Fuel", ELEKTRICHESKIYE STANTSII, No 3, 1981. Since assignment of nuclear fuel to the category of producer goods can distort economic evaluations, it is suggested that the various forms of nuclear fuel serving whatever purpose in the plant be classified as working capital. A procedure for distribution of expenditures is developed in which consideration is taken of both the energy efficiency of further utilization of secondary nuclear fuel and the level of expenditures involved. The level of long-term working capital set aside for the nuclear electric plant should be reduced on the basis of appropriate organization of intrasectoral calculations for utilization of nuclear fuel that account for efficiency of using it both in the nuclear facility and in the fuel cycle of the nuclear power association as a whole, rather than on the basis of hasty evaluation of the part of the expenditures for nuclear fuel that is determined by the level of surplus value. [201-6610]

UDC 621.039.62.12

TOKAMAK-15: MAIN CHARACTERISTICS AND RESEARCH PROGRAM

Moscow ATOMNAYA ENERGIYA in Russian Vol 52, No 2, Feb 82 pp 101-108

BELYAKOV, V. P., GLUKHIKH, V. A., KAVUN, A. M., KADOMTSEV, B. B., KOVALENKO, V. D., KOSTENKO, A. I., MALYSHEV, I. F., MONOSZON, N. A., POKOV, G. N., STAVISSKIY, B. A. and STRELKOV, V. S.

[Abstract] The article gives the text of a report to the Second All-Union Conference on Engineering Problems of Fusion Reactors held in Leningrad, 23-25 June 1981. Technical data are given on the T-15 tokamak facility, the first fusion research reactor of its class to use superconductors. The device is to produce a plasma with thermonuclear parameters close enough to ignition that reliable extrapolation to a plasma with ignition will be feasible. The design stage is now complete, and construction has been started. The major radius of the plasma column is 2.43 m, and the minor radius is 0.7 m. In the nominal mode of operation, the toroidal magnetic field will be 3.5 T, and the current in the plasma will be 1.4 MA. In the second phase, it has been planned to increase the toroidal field to

4.5-5 T, and the plasma current to 2-2.3 MA, and to raise the power of additional plasma heating from 10 to 15 MW. The superconductive toroidal field winding will consist of 24 coils connected in pairs. Each coil is made up of six two-layer disk sections enclosed in a stainless steel shell. The coil material will be $Nb_3Sn$ with liquid helium cooling. Structural details are also given on the inductor, control windings, discharge chamber, fast atom injection system, microwave heating system, evacuation, gas-supply, cryogenic support and control systems. The total area required for the installation will be about 15,000 sq. m. A five-year research program will cover aspects of stability, transfer processes, heating, discharge and interaction between the plasma and wall materials. Figures 7.
[202-6610]

UDC 621.039.646

PRINCIPAL PHYSICAL AND ENGINEERING PROBLEMS OF DEVELOPING TOKAMAK WITH STRONG MAGNETIC FIELD AND ADIABATIC PLASMA COMPRESSION

Moscow ATOMNAYA ENERGIYA in Russian Vol 52, No 2, Feb 82 pp 108-112

AZIZOV, E. A., ALEKSEYEV, Yu. A., BREVNOV, N. N., VELIKHOV, Ye. P., GLEBOV, I. A., GLUKHIKH, V. A., DEMICHEV, V. F., KADOMTSEV, B. B., KARASEV, B. G., KRYLOV, V. A., LARIONOV, B. A., MALYSHEV, I. F., MOZIN, I. V., MONOSZON, N. A., ODINTSOV, V. I., PIS'MENNYY, V. D., PUTVINSKIY, S. V., RUTBERG, F. G., SPIRCHENKO, Yu. V., STOLOV, A. M. and CHUYANOV, V. A.

[Abstract] The article gives the text of a report to the Second All-Union Conference on Engineering Problems of Fusion Reactors held in Leningrad, 23-25 June 1981. An outline is given of the results of feasibility studies on experimental tokamaks with strong field and adiabatic compression for producing plasma with parameters close to ignition conditions based on the latest ideas about transfer processes and the limiting value of beta. The toroidal field winding would be made of chromium bronze with maximum current of 830 kA, maximum magnetic field on the surface of 21.2 T and maximum surface temperature of 230°C. The poloidal field would be shaped without a ferromagnetic core by using an inductor winding, compression winding, two equilibrium windings and two windings for correcting the initial field. The overall dimensions of the electromagnet system would be height of 6 m and diameter of 2.5 m with a mass of 130 metric tons. Since the power requirements of the electric supply system are so enormous that 4-6 hours will be required between pulses at full power, a lower-power mode will be provided with intervals of about 10 minutes between pulses. In full-power operation, the energy transferred to the load will be about 150 MJ at maximum power of about $1.3 \cdot 10^{10}$ W. Research is now being done on various kinds of vacuum chambers of metallic construction without insulating layers. Figures 6, references 2: 1 Russian, 1 Western.
[202-6610]

UDC 621.039.624

# HYBRID REACTOR WITH AMBIPOLAR PLASMA CONFINEMENT (TROL PROJECT)

Moscow ATOMNAYA ENERGIYA in Russian Vol 52, No 2, Feb 82
(manuscript received 10 Jul 81),pp 113-117

VASIL'YEV, N. N., GOLOVIN, I. N., NEDOSPASOV, A. V. and SHATALOV, G. Ye.

[Abstract] The paper summarizes results of research on a hybrid reactor with ambipolar plasma confinement which was begun in the Soviet Union in 1978 (project TROL). The facility is intended for producing electric energy and accumulating secondary nuclear fuel: plutonium and tritium. Functionally, five traps can be distinguished in the reactor: a central trap (solenoid) in which the fusion reaction takes place, barrier traps at the ends of the solenoid that ensure longitudinal confinement of ions, and two end traps with quadrupole magnetic field intended for stabilizing sideways instability of the plasma throughout the entire reactor. The proposed design has thermal power of 6500 MW, gross electric power of 2400 MW, net electric power of 1550 MW and fusion power of 700 MW. Plutonium production is 3.8 metric tons per year. The energy conversion system is a steam turbine and cooling is by water and water vapor. The reactor is 134 m long and 10 m in diameter. The authors describe the design of the magnet system and the injection system. The principal advantage of the hybrid design over tokamaks is steady-state operation, which makes the problem of material fatigue no more complicated than for conventional fission reactors. Erosion of the first wall in the central trap may be an order of magnitude less than for tokamaks, since charged particles are evacuated beyond the limits of the reactor zone. The ambipolar reactor does not have the destructive instabilities inherent in tokamaks. Also, construction is potentially much simpler and less expensive than for tokamaks. Figure 1, references 17: 7 Russian, 10 Western.
[202-6610]

UDC 539.1.074.8:539.172.4

# NUCLEAR-PHYSICS CHARACTERISTICS OF NEUTRON DETECTORS IN AKN-T ARRAY

Moscow ATOMNAYA ENERGIYA in Russian Vol 52, No 2, Feb 82
(manuscript received 16 Jan 81) pp 136-137

YARYNA, V. P. and GALIYEV, N. B.

[Abstract] The paper gives the results of a study of neutron resonance self-shielding of activation detectors in the form of disks and verification of the integrated resonant characteristics of activation reactions $^{197}Au(n, \gamma)^{198}Au$, $^{139}La(n, \gamma)^{140}La$, $^{59}Co(n, \gamma)^{60}Co$, $^{55}Mn(n, \gamma)^{56}Mn$ and $^{63}Cu(n, \gamma)^{64}Cu$. Activation detectors 10 mm in diameter were irradiated under identical conditions in thermal neutron fields on TVR and IRT-2000

reactors. The coefficients of self-shielding $G_p$ were determined by comparing reaction rates $R^{Cd}$ in detectors of different thicknesses shielded by cadmium, where

$$R^{Cd} = \phi_{ep}(I_\beta^{1/v} + G_p I'_\beta). \quad (1)$$

Here $\phi_{ep}$ is epithermal neutron flux density, $I_\beta^{1/v}$ and $I'_\beta$ are the resonant integral of the 1/v-th part of the cross section and the excess (over the 1/v-th part) resonant integral of the reaction in the epithermal neutron spectrum proportional to $E^{-(1-\beta)}$ (E is neutron energy). It was established by a special experiment that $\beta = 0.00 \pm 0.01$. The relation between the coefficient of self-shielding and detector thickness was approximated by the expressions

$$\begin{aligned} G_p &\quad 1/\sqrt{1 + 2.88Y - 8.2Y^2} \text{ for } Y = 0\text{-}0.1 \\ G_p &= 0.964 - 0.594Y + 0.26Y^2 \text{ for } Y = 0.1\text{-}0.7 \\ G_p &= 0.604 - 0.202 \ln Y \text{ for } Y = 0.7\text{-}4.0, \end{aligned} \quad (2)$$

where Y is detector thickness in units of the mean free path of neutrons in the specimens. The dependence of experimental values of $R^{Cd}$ on detector thickness $\delta$ was approximated with consideration of (1) and (2), assuming that $Y = \delta K_\delta$, and selecting coefficient $K_\delta$ to minimize the sum of the squares of deviations of the measured reaction rates from the approximated values. The results the experiments gave values of $\phi_{ep} = 7.90 \cdot 10^6$, $7.98 : 10^6$, $7.87 \cdot 10^6$ and $7.96 \cdot 10^6$ neutrons/$(cm^2 \cdot s)$ for gold, cobalt, manganese and copper detectors respectively. This shows good agreement in view of the error of 1-3% in determining reaction rates. Therefore it is recommended that the values of nuclear constants given in the article be used for neutron detectors in the AKN-T array developed by the All-Union Scientific Research Institute of Physicotechnical and Radiotechnical Measurements. Table 1, references 3: 2 Russian, 1 Western.
[202-6610]

UDC 621.039.554(063)

NUMERICAL ANALYSIS OF PARAMETERS THAT INFLUENCE SPHERICAL FUEL ELEMENT MOTION IN HIGH-TEMPERATURE GAS-COOLED REACTOR CORES

Minsk VESTSI AKADEMII NAVUK BSSR: SERYYA FIZIKA-ENERHETYCHNYKH NAVUK in Russian No 1, Jan-Mar 82 (manuscript received 6 Apr 81) pp 17-22

SAVUSHKIN, I. A., RAVKOVA, Ye. I., SYRKUS, N. P., GOL'DBERG, M. M., ROZINA, K. A. and STARIZNYY, Ye. S., Moscow State Pedagogical Institute imeni A. M. Gor'kiy; Physicochemical Institute imeni L. Ya. Karpov, Moscow

[Abstract] A model is developed for numerical analysis of fuel element movement in the core of a pebble-bed HTGCR. In the proposed tube flow model,

the core is broken up by surfaces of revolution of trajectory curves into partial volumes in the form of bodies of revolution that are called stream tubes. Within the limits of a stream tube, the radial component of velocity is taken as constant, and only the vertical component is considered. In analyzing the influence of various parameters on pebble bed movement, the prototype design is taken as the thorium high-temperature reactor on a scale of 1:15. The fuel elements were modeled by steel balls 4 mm in diameter. Parameters considered include the configuration of the core, relative height of the pebble layer, size of fuel elements, friction and density of fuel element material. The results show that these parameters have a considerable effect on pebble motion, and that they must be considered when calculating the neutron-physics characteristics of a high-temperature gas-cooled reactor and the radiation characteristics of the uranium radiation loop. Figure 1, tables 6, references 10: 5 Russian, 5 Western. [203-6610]

## MHD COMBUSTION PRODUCTS DRIVE STEAM-TURBINE GENERATORS

Riga SOVETSKAYA LATVIYA in Russian 2 Feb 82 p 2

[Article by Academician V. Kirillin, chairman of the USSR Academy of Sciences Scientific Council on the Complex Problem of "Thermal Physics", and Academician A. Sheyndlin, director of the USSR Academy of Sciences High-Temperature Institute: "Power Plant of the Future"]

[Text] The chemical energy of organic fuel, as well as nuclear energy, are now converted to electrical energy in a number of steps: the fuel is first obtained, which is then converted to mechanical energy, and finally to electricity. It has been possible to increase efficiency at modern power plants only to 40%. This means that over 60% of the heat contained in the fuel is lost.

It is not without justification that the solution of the problem of improving the utilization of organic and nuclear fuel resources significantly is associated with the introduction of a new type of power plants which provide the capability of converting energy at significantly higher temperatures. Power plants using magnetohydrodynamic (MHD) generators are among the most promising power plants in this respect. Experimental installations with MHD generators began to be built in this country over 20 years ago. The problem consisted primarily of obtaining high temperature combustion products. When small amounts of easily ionized substances, usually containing alkali elements, are added, these combustion products become electrically conducting, i.e., they are converted to a low-temperature plasma. This plasma, which has a temperature of about 3000° Kelvin at the beginning of the process, serves as the working substance of the MHD generator, which converts thermal energy directly to electrical. The plasma is accelerated in nozzles to high velocities of the order of 1000 meters per second, and is then passed through the MHD generator channel, which is located in a strong magnetic field.

According to Faraday's law, the movement of an electrically-conducting gas (low-temperature plasma) through a strong magnetic field results in the direct conversion of some of the gas energy to electricity.

The temperature of the combustion products at the output of the MHD generator is still extremely high. Therefore, the plasma is transmitted to the generator in an ordinary steam-turbine plant.

A magnetohydrodynamic power plant is thus a two-stage installation. The first stage is the MHD generator, where part of the thermal energy of the low-temperature plasma is converted to electricity. The second stage is an ordinary steam-turbine plant in which the remaining heat from the combustion products which have passed through the MHD generator are also converted to electricity.

The efficiency of an MHD power plant may be as high as 50% now, and will reach 60% later, after the components of MHD plants are improved. Consequently, the relative increase in efficiency of this type of plant over a thermal plant can amount to 20-25%, which provides significant fuel savings.

The first U-02 Soviet MHD plant was built in 1964 in Moscow, at a thermal power plant. The construction of the U-25 experimental industrial plant of the USSR Academy of Sciences High-Temperature Institute was completed in 1971. It reached its design capacity of 20 megawatts in 1975.

The years of experimental operation of the U-25 plant demonstrated the usability of its elements. Thanks to operational development of the equipment, the parameters of all of the basic systems reached their design values, and in many cases exceeded them.

Experience gained in converting thermal energy to electricity in the U-02 and U-25 MHD plants made it possible several years ago to start work on the creation of the world's first industrial MHD unit. Completion of the construction of this unit is planned for the present five-year plan. The unit will consist of a 250 megawatt MHD generator and a standard 300 watt steam turbine. According to the calculations of specialists, the MHD unit will provide fuel savings of about 20% over power plants using an ordinary thermal scheme.

The MHD unit which is being built at the Ryazan' State Power Plant is designed to operate with natural gas. However, it will make it possible to develop units and assemblies which in time can be used in coal-fired units.

The basic prospects of MHD power plants are associated with the use of coal, in terms of reserves of which our country is the world leader.

The start-up of the first industrial MHD unit at the Ryazan' State Power Plant will be the birthday of large-scale MHD power engineering, which will make it possible to increase the efficiency of fuel utilization in the future.

6900
CSO: 1861/185

UDC 621.311.29:536.1

# INCREASING ELECTRICAL STRENGTH OF INTERELECTRODE INSERT IN MHD-GENERATOR CHANNEL BY AIR BLAST

Kiev DOKLADY AKADEMII NAUK UKRAINSKOY SSR, SERIYA A: FIZIKO-MATEMATICHESKIYE I TEKHNICHESKIYE NAUKI in Russian No 2, Feb 82
(manuscript received 29 Sep 81) pp 75-77

BAZEYEV, Ye. T., MAZUR, N. I., MIROSHNICHENKO, A. A. and SHCHEGOLEV, G. M., Institute of Technical Thermophysics; Institute of Electrodynamics, both of UkSSR Academy of Sciences

[Abstract] An experimental study was made to determine the effect of thermal protection by air blast on the electrical strength of the interelectrode insulating insert in a plasmodynamic channel. Tests were performed on the K-1 MHD generator at the Institute of Electrodynamics. The inserts were made of corundum and periclase with 10-20% porosity, produced at the Institute of Problems in Materials Science (UkSSR Academy of Sciences). The plasma stream in the channel had a velocity of approximately 800 m/s and a temperature of 2500-2750 K, with the thermal flux density varied from 1.30 to 2.65 $MW/m^2$. The relative air blast intensity was up to 4% of the plasma stream intensity. The breakdown voltage and thus the safety margin were raised by 25-40%, as a result of air blast through the porous insert, as compared with an only 10% increase by doubling the width of a solid insert, at an electrode current density of 7 $A/cm^2$. The insert did not become defective after 5 hours of testing, 70 min under nominal operating conditions. Article was presented by Academician I. T. Shvets, UkSSR Academy of Sciences. Figures 2, references 7: 6 Russian, 1 Western.
[211-2415]

UDC 662.959.2

EXPERIENCE IN ADAPTATION AND OPERATION OF BK 320-140GM6 HEADER BOILERS HEATED BY FURNACE WITH INTERSECTING JETS

Moscow TEPLOENERGETIKA in Russian No 2, Feb 82 pp 17-21

DANCHENKO, Yu. Ye., engineer, (deceased), LAVROV, Ye. S., engineer, YUSUPOV, R. U., engineer, YENYAKIN, B. P., engineer, IZYUMOV, M. A., candidate of technical sciences, and ROSLYAKOV, P. V., candidate of technical sciences, Dyagilevskaya TETs; Moscow Regional Administration of Power System Management; Mobile Pumping Station, Moscow Regional Administration of Power System Management and Trouble Shooting; and Moscow Institute of Power Engineering

[Abstract] Drum-type BKZ 320-140 GM6 boilers with natural circulation built at the Barnaul boiler manufacturing plant generate up to 320 t/h of steam at 13.72 MPa and 570°C. They are designed for operation with a furnace burning various fuels from natural gas and mazut to low-grade coal with removal of liquid slag. Burners and air nozzles are arrayed so as to produce intersecting jets. An outstanding feature of this furnace is that formation of nitrogen oxides and sulfur-trioxide is inhibited, the $NO_x$ content in flue gases increasing hardly at all as the excess air ratio varies from 1.03 to 1.1 and increasing only slightly as the load increases up to full level. The technical-economic boiler performance indicators, based on operating experience in the Dyagilevskaya TETs, meet or exceed design specifications. With mazut as fuel and with 1.08 excess air ratio behind the convective steam preheater, the boiler operates at efficiencies up to 92.22%. Figures 4, tables 3, references 4 Russian.
[183-2415]

UDC 621.311.22

EXPERIENCE IN ERECTION, ADAPTATION AND OPERATION OF ZAPOROZH'YE GRES

Moscow TEPLOENERGETIKA in Russian No 2, Feb 82 pp 7-13

NOSUL'KO, D. R., engineer, and BUGASOV, A. V., engineer

[Abstract] The 3600 MW Zaporozh'ye GRES is a fossil-fuel plant consisting of four 300 MW first-generation (1972-73) units and three 800 MW second-generation (1976-77) units. All units were installed ahead of schedule: the 300 MW units 15 months earlier and the 800 MW units 3 months earlier. As a result of equipment redesign and adaptation, affecting especially burners and heat exchangers but also various key auxiliaries, and with the aid of properly trained personnel, tremendous progress has been made from 1973 and 1976 to 1980 in both fuel economy and plant utilization. During the respective periods the fuel consumption rate decreased from 368.4 to 336.9 g/(kW.h) in the 300 MW units and from 340.13 to 320.9 g/(kW.h) in the 800 MW units,

while in the case of the 800 MW units the utilization factor increased from 49.72 to 73.22% and the availability factor increased from 74 to 87.78%. Figures 9.
[183-2415]

UDC 621.311.22

ADAPTATION OF EQUIPMENT IN REFTINSKIY GRES OPERATING WITH POLYSOL FUEL

Moscow TEPLOENERGETIKA in Russian No 2, Feb 82 pp 4-7

GERVITS, M. B., engineer, IVANOV, Yu. V., engineer, ZHIGAL'SKIY, M. T., engineer, and SOKOLOVSKAYA, L. P. Reftinskiy GRES

[Abstract] The 3800 MW Reftinskiy GRES in the Central Urals is the largest fossil-fuel electric plant in the Soviet Union running on low-cost Ekibastuz polysol coal. It consists of six 300 MW and four 500 MW units with PK-39-II, P-57-II, P-57-III boilers built at the Podol'sk machine manufacturing plant, K-300-240-1, K-300-240-2, K-500-240-2 turbines built at the Khar'kov turbine manufacturing plant, TGV-300, TGV-500 generators built at the Khar'kov "Elektrotyazhmash" plant and TVM-500 generators built at the "Sibelektrotyazhmash" plant. During the past 10th Five-Year-Plan period the 300 MW units in this power plant have become the most economic solid-fuel power units in the country. This was achieved by redesign of low-pressure, medium-pressure, and high-pressure cylinders, replacement of scrapers with screw conveyers for coal feed, protection of pulverizers and burners against wear, acceleration of boiler cooling, and shift of the first steam tap in the main turbine to behind the eighth stage. Equipment of the 500 MW units in this plant, namely coal grinders, blowers, exhaust fans, and condensate pumps, was properly conditioned during installation, including protection against abrasion by ash. Particularly important was also optimization of the circulatory water supply to condensers of the main turbine and to the feed-pump drive turbine. Much attention in this electric power plant is paid to implementing the principle of socialist competition. Figures 6, table 1.
[183-2415]

UDC [621.313.32+537.312.62]:531.225.001.2

# INVESTIGATION OF ELECTROMECHANICAL TRANSIENT PROCESSES IN CRYOGENIC ELECTRIC MACHINES

Moscow IZVESTIYA AKADEMII NAUK SSSR: ENERGETIKA I TRANSPORT in Russian
No 1, Jan-Feb 82 (manuscript received 6 Feb 81) pp 50-55

KOVARSKIY, M. Ye., RUBINRAUT, A. M. and GEMINTERN, V. I., Moscow

[Abstract] A mathematical model is given for a cryogenic AC machine. Variation of rpm is taken into consideration by a system of differential equations in a coordinate system fixed to the stator with the addition of Lagrange equations for the rotating masses. Analysis of resultant torques shows that calculation of the loads acting on components of cryogenic electric machines must take consideration of both electromagnetic and dynamic moments, since the latter take on decisive significance for certain ratios between the flywheel masses of the runner and the turbine. For generator-turbine systems where the inertia of the turbine is small compared with the generator runner, an electromagnetic shield does not completely relieve the suspension of the superconductive field winding due to inertial torques. Figures 4, references 5 Russian.
[204-6610]

UDC 621.007.52

## RULES FOR BUILDING TRANSMISSIONS INTO AUTOMATIC MANIPULATORS AND INDUSTRIAL ROBOTS WITH DRIVE ON BASE PLATE

Moscow VESTNIK MASHINOSTROYENIYA in Russian No 4, Apr 82 pp 3-7

OVAKIMOV, A. G., doctor of technical sciences

[Abstract] Design of differential transmissions for automatic manipulators and industrial robots of any kind, with both rotational and translational kinematic pairs, is considered in the case where the drive motor must, for structural reasons, be mounted outside on the base plate. The problems of statics, kinematics and control have already been solved. Here universal rules are established for constructing such transmissions. The solution of this problem involves using the determinant matrix of the corresponding system of linear first-order differential equations, ensuring controllability with the necessary number of degrees of freedom, and selecting the appropriate types of coupling for the various shaft pairs. Figures 4, references 5 Russian.
[210-2415]

UDC 621.937.02:621.315.592

## MODEL AD2 MACHINE TOOL FOR CUTTING CRYSTALS

Leningrad OPTIKO-MEKHANICHSKAYA PROMYSHLENNOST' in Russian No 1, Jan 82 (manuscript received 20 Dec 79) p 61

DYUDIN, P. G. and BELYY, N. N.

[Abstract] The model AD2 machine tool is intended for precision cutting of semiconductor crystals (Ge, InSb, ternary solid solutions) and other brittle materials. It can also cut multilayer structures with arbitrary patterns of alternate conducting and nonconducting layers. It produces minimum strain with minimum loss of material. The horizontal reciprocating motion of the slide carriage is very smooth and precise, and vertical motion

of the feed table has eight possible speeds. Both are regulated. The machine tool can be adjusted for cutting blanks of sizes from 30x30x30 mm to 0.05x0.05x0.05 mm. The cutting process is monitored through an MBS-2 microscope. The machine tool weighs 25 kg, measures 250x395x395 mm and operates from a 110 VDC power supply with either manual or semiautomatic control. Figure 1, table 1, reference 1 Russian.
[184-2415]

UDC 62-52

PIEZOELECTRIC STEPPER MOTOR FOR ALIGNMENT OF COMPOUND TELESCOPE MIRROR

Leningrad OPTIKO-MEKHANICHESKAYA PROMYSHLENNOST' in Russian No 1, Jan 82 (manuscript received 26 Dec 80) pp 59-60

KRYUKOV, V. I., NIKOLAYEV, P. V., PRIVEZENTSEV, Yu. S., RESOVSKIY, V. A., RODIONOV, A. K. and SYCHEV, V. V.

[Abstract] The servomechanism for alignment of compound telescope mirrors must feature high positioning accuracy (fraction of millimeter) and relatively long travel (several millimeters) as well as appropriate dynamic characteristics under a load of several kilograms. Combining the reverse piezoelectric effect and step motion appears to reconcile these requirements. A piezoelectric stepper motor for this application has been built consisting of a piezoceramic plunger, whose length can be varied depending on the applied voltage, and two controllable pawls. Its static characteristics under a load of 4 kg were measured by the direct method in three experiments, with the voltage applied to the plunger as the input signal and the displacement of the plunger as the output signal. In the first experiment plunger displacement was measured as a function of the input signal with the lower pawl locked. In the second experiment plunger displacement was measured during step motion with both pawls and plunger controlled by square voltage pulses. In the third experiment the effect of pawls on the positioning acc racy was determined. Although the results of the last two experiments indicate that the positioning smoothness and accuracy of this sevice are still inadequate for alignment of compound mirrors, the principle is sound and satisfactory performance can be achieved with operation in a combined continuous-discrete mode. Figures 2, references 5 Russian.
[184-2415]

UDC 629.124.74.015.64.002:622.242

MANUFACTURE OF STABILIZING COLUMNS FOR SEMISUBMERSIBLE DRILLING RIGS

Leningrad SUDOSTROYENIYE in Russian No 2, Feb 82 pp 52-53

SUBBOTIN, B. A. and BORISENKO, V. I.

[Abstract] Each stabilizing column for a semisubmersible drilling rig is subdivided into four segments 9.8 m in diameter. Their assembly is facilitated by pairing them into upper and lower tiers. Each tier contains longitudinal and transverse internal members, platforms and semiplatforms, chain boxes, hoisting gear and other equipment. Joints between tubular and hollow prismatic elements that are technologically difficult to secure are a special feature of these structures. Such stabilizing columns are manufactured on a line with five successive stations: three for assembly and automatic welding of column segments and shells with necessary bending and containerization, two for fabrication of internal members in upper and lower tiers. Subassemblies are conveyed by crane and trailer. The assembly line has been laid out to allow for maximum automation and economy of column manufacture, including minimum waste of metal, with excellent opportunities for organizing the labor force in teams with wage incentives for productivity. Figures 3.
[206-2415]

UDC 629.124.74.061.014.72:622.242

SPECIAL FEATURES OF BALLAST SYSTEM FOR SEMISUBMERSIBLE DRILLING RIGS

Leningrad SUDOSTROYENIYE in Russian No 2, Feb 82 p 29

BENZORUK, V. A. and VYAL'TSEV, B. A.

[Abstract] The semisubmersible drilling rig "Shel'f-1" operates in two basic positions: 5.5 m scouting draught and 14 m working draught (up to 22.5 m in an emergency). Precise operation of crane and differential is ensured by an automatic feed regulator. The ballast system has been designed with a distributing manifold and with all fittings in the pump compartment of one pontoon. One special feature of such a drilling rig is the large, 18.5 m long, distance from a pontoon to the main deck. The large mass of correspondingly long air pipes, for measurements, has been reduced by installation of a load dumping channel on the compressor side of the ballast pipe (USSR Patent disclosure No 694414). The ballast system includes, in addition to cisterns, also slide valves with electric drive, regulating valves with hydraulic drive, pumps, Kingston valves, and a pipe to the cooling system. Figure 1, reference 1 Russian.
[206-2415]

UDC 621.5.013.4

ABSORPTION-TYPE 6000 kW REFRIGERATOR SET WITH LOW-TEMPERATURE HEAT FOR COOLING WATER

Moscow TEPLOENERGETIKA in Russian No 2, Feb 82 pp 64-66

BYKOV, A. V., doctor of technical sciences, ROZENFEL'D, L. M., doctor of technical sciences, SHMUYLOV, N. G., candidate of technical sciences, KALNIN', I. M., candidate of technical sciences, and VOL'NYKH, Yu. A., engineer, All-Union Scientific Research Design Engineering and Technological Institute of Refrigeration Machinery Manufacture

[Abstract] The largest in the world 600 kW absorption-type refrigerator set operating with subcooled lithium bromide in water solution has been built after extensive scientific research and experimental design studies at the laboratory of the Institute of Thermophysics (Siberian Department, USSR Academy of Sciences). It consists of a generator-condenser module and an absorber-evaporator module. The absorber is split into two compartments, a subcooling heat exchanger and a hollow absorption chamber, designed to facilitate an adiabatic-isobaric process. Aqueous solution of LiBr proceeds from the generator to the absorber, where it is subcooled and absorbs coolant vapor coming from the evaporator. The evaporator has louvres on the sides to prevent dripping, the condenser tubes are of the ribbon type with ducts for vapor and a tap at the bundle center for blow-off of vapor-air mixture. Hot water at 90-95°C from the technological process in a TETs serves as the heating medium. The cold water at 22-26°C serves as coolant for the technological process at lower temperature. The refrigerator performance depends largely on the temperatures of heating and cooling water, theoretically 6200 kW and practically 4200 kW being reached with 750 $m^3/h$ of water cooled to 8.6°C at the evaporator outlet. Figures 2, table 1, references 3 Russian.
[183-2415]

UDC (621.311.22+621.311.25:621.039)-53

BASIC-CASE CALCULATION OF THROUGHPUT CHARACTERISTICS OF REGULATORS IN AES'S AND TES'S

Moscow ENERGOMASHINOSTROYENIYE in Russian No 3, Mar 82 pp 4-6

AYZENSHTAT, I. I., candidate of technical sciences, and BLAGOV, E. Ye., engineer

[Abstract] The throughput capacity, the most universal characteristic of regulators, is calculated for two basic cases applicable to AES's and TES's. The first case covers regulators with a change in the flow rate of the control fluid as the input quantity. The second case covers regulators with a change in the pressure or in the flow rate of the main fluid as the input

quantity. Regulator design and performance calculations are based on relevant hydrodynamic and thermodynamic relations for fluidic media such as water (incompressible) or steam (compressible). A typical example illustrates how the design of a regulator can be optimized on the basis of its static characteristic, by the conventional linearization method involving first differentiation and then integration with respect to the throughput capacity. Figure 1, tables 2, references 4: 3 Russian, 1 Western.
[208-2415]

UDC 621.224.35+669.017:539.4

## IMPROVED FATIGUE STRENGTH OF RUNNERS IN NEW DESIGNS FOR WATER TURBINES WITH ADJUSTABLE BLADES

Moscow ENERGOMASHINOSTROYENIYE in Russian No 2, Feb 82 pp 16-17

BABANOV, O. S., engineer, ARONSON, A. Ya., candidate of technical sciences, and BABACHENKO, V. Ye., engineer

[Abstract] The blade adjusting mechanism in water turbines is subject to fritting corrosion and to alternating forces due to pressure fluctuations in the servomotor cavities in the runner. Studies and analysis of turbine runners with adjustable blades in various hydroelectric power plants, first in Verkhnetulomskiy in 1967, by staff members of the Leningrad Metal Plant and then by staff members of the Central Boiler and Turbine Institute have established that the reliability of the blade adjusting mechanism can be ensured only be designing into its vulnerable components such as lever pin and shackle a sufficient safety margin that combines corrosion resistance with fatigue strength. One approach is to make the vulnerable components of stainless steel with high chromium and nickel content rather than of pearlitic steel, or to cover the vulnerable surfaces with protective plating. Another approach is to press on protective sleeves with an interlayer of fiberglass-reinforced epoxy compound. References 12 Russian. [207-2415]

UDC 621.165.001.539.433

## EFFECT OF SEPARATORS ON VIBRATION STRESSES IN AXIAL COMPRESSOR WORKING BLADES

Moscow ENERGOMASHINOSTROYENIYE in Russian No 2, Feb 82 pp 10-13

BOGORADOVSKIY, G. I., candidate of technical sciences, STEPANOV, A. M., candidate of technical sciences, and VEDISHCHEV, A. F., engineer

[Abstract] An experimental study of two types of separators was made to determine their effect on vibration stresses in blades of multistage axial

compressors for gas turbines under various operating conditions. A comb separator was installed above the steel working blades of an 11-stage 6000 kW - 5225 rpm prototype compressor. A slit separator with special connecting ducts was installed above the duralumin working blades of an 8-stage 40,000 kW - 12,500 rpm model compressor. The results of tests have been evaluated so as to describe the dependence of dynamic stresses on the normalized speed, the normalized air mass flow rate, and the compression ratio. They indicate that separators in the first stage reduce vibrations by a factor of 1.2-2.5 from the dangerous level, without detrimentally affecting the second stage. Installation of separators in the next stages can also be recommended. Figures 5.
[207-2415]

UDC 62-50:519.2

METHOD OF BALANCING DISCRETELY DISTRIBUTED ROTATING MASSES

Moscow ENERGOMASHINOSTROYENIYE in Russian No 2, Feb 82 pp 4-5

STOYAN, Yu. G., doctor of technical sciences, SOKOLOVSKIY, V. Z., candidate of technical sciences, and YAKOVLEV, S. V., engineer

[Abstract] A method of balancing discretely distributed rotating masses has been developed that yields correct results not only for water turbine runners with a few blades (10-20) but also for steam turbine runners with many blades (70-200). It is based on exact formulation of the problem in terms of minimization of the unbalance functional, the latter defined on a set of permutations with constraints due to technological factors. The problem is solved by a method of directional random search through converging neighborhoods, with stochastic sampling of permutations, with introduction of a metric structure and with assumption of the law of distribution of functional values. The "Balans-78" program, written for a YeS-1033 computer, has been tested on several steam turbines and is now used by the Planning Department at the Khar'kov turbine manufacturing plant. The authors thank N. D. Chernov, A. V. Trzhetsinskiy and V. A. Glikson on the staff of the Khar'kov turbine manufacturing plant imeni S. M. Kirov for helpful consultations and assistance in implementing the "Balans-78" program complex. References 6 Russian.
[207-2415]

UDC 621.165.74.+534.2

ENSURING VIBRATION RESISTANCE OF BLADING IN OR-12P TURBINE DRIVES DURING OPERATION OF 300 MW POWER UNITS WITH SLIDING INITIAL PRESSURE

Moscow ENERGOMASHINOSTROYENIYE in Russian No 3, Mar 82 pp 29-30

AKKAD'YEV, D. A., candidate of technical sciences, KARPIN, Ye. B., candidate of technical sciences, LUKASHEVICH, V. E., engineer, and TEMKIN, S. G., engineer

[Abstract] Changeover of 300 MW power units to operation with sliding initial pressure of live steam requires a careful vibration and stress analysis of blading in OR-12P turbine drives, to ensure reliability at higher speeds of the feed pump. Data from the Konakovo GRES and the Kostroma GRES indicate that the speed of drives increases with increasing turbine power, while the life of these drives becomes shorter after such a changeover. According to data from the Kirizhi GRES and the Lukoml' GRES, tensometric measurements made on the blading in the seventh stage with a 152 mm long variable profile reveal fundamental tangential vibrations at 450-490 Hz, axial disk vibrations at 650-850 Hz, second-harmonic tangential vibrations at 220-2300 Hz (only in Lukoml' GRES) and torsional vibrations at 2800-3300 Hz (only in Kirizhi GRES). All vibrational stresses are within safe limits but, according to the Campbell stress distribution diagram, some blades in the seventh stage could have passed through resonance at the second-harmonic frequency of tangential vibrations. This should be avoided to prevent accidental damage. Figures 4, references 3 Russian.
[208-2415]

UDC 621.224.01

STUDIES OF HORIZONTAL AXIAL-FLOW WATER TURBINES

Moscow ENERGOMASHINOSTROYENIYE in Russian No 3, Mar 82 pp 6-9

VARLAMOV, A. A., engineer, and ZHAGRIN, B. M., engineer

[Abstract] Model studies were done on horizontal axial-flow water turbines, particularly one with enclosed construction, as a basis for solving performance and reliability problems. The object of the research was to determine distributions of forces and torques on runner blades, including the effect of weight, and the velocity distribution before the guide wheel. The weight of moving blades causes pulsations, the weight of guide vanes causes nonuniformity of forces and moments. Asymmetric narrowing of the flow channel near the shroud causes nonuniformity of the velocity distribution. Funneling due to twisting of the stream will cause violation of similarity laws for the prototype turbine when the Froude criterion has not been satisfied

in simulation of flow before entrance to the model turbine. Figures 4, references 6: 5 Russian, 1 Western.
[208-2415]

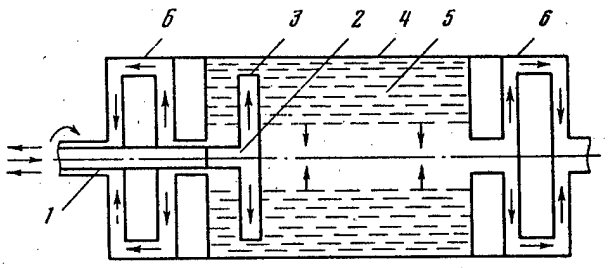
UDC 621.313.322-81.002.12

## THERMODYNAMIC ANALYSIS OF CRYOTURBOGENERATOR RUNNER COOLING ARRANGEMENT

Moscow IZVESTIYA AKADEMII NAUK SSSR: ENERGETIKA I TRANSPORT in Russian
No 1, Jan-Feb 82 (manuscript received 27 May 80, after revision 24 Mar 81)
pp 38-43

DANILEVICH, Ya. B., ROZENFEL'D, L. M., ZHURAVLEV, G. S. and TUTAYEV, V. A., Leningrad

[Abstract] The authors consider the cryoturbogenerator runner cooling arrangement shown in the diagram. Liquid helium enters the rotor under greater than atmospheric pressure and is partially evaporated as it travels through the outer tubing, forming a two-phase mixture with a certain vapor content at the entrance to radial rotating tube 2. Centrifugal forces separate the flow at the periphery 3, and the liquid helium collects on the outside of runner 4 in region 5 where the superconductive winding is located. The vapor entering from the radial tube and produced by boiling in the vicinity of the superconductive windings is removed from the axial region of the runner through heat bridges 6, and returned to the outer helium loop. The behavior of thermodynamic processes in this system is analyzed by using a temperature-entropy diagram. Analysis of the helium cycle is based on one-dimensional equations of momentum and energy. It is shown that the action of centrifugal forces in the operating runner leads to processes of expansion and compression of the two-phase helium, resulting in an open thermodynamic cycle. The parameters of the coolant in the working processes have a considerable effect on the operability of the runner and the flowrate of liquid helium. The influence of centrifugal forces on the efficiency of thermophysical processes in the runner depends in large measure on the nature of the thermodynamic cycle. Stand tests of a superconductive generator with this arrangement confirm the results of thermodynamic analysis: mass flowrate of helium through the heat exchangers and qualitative distribution of temperatures in the runner. Figures 3, references 5: 3 Russian, 2 Western.




[204-6610]

UDC 531.383

# ERRORS OF GYROCOMPASS WITH INDIRECT CORRECTION DUE TO IMPRECISE INPUT DATA ON SHIP'S LATITUDE, SPEED AND COURSE

Leningrad IZVESTIYA VYSSHIKH UCHEBNYKH ZAVEDENIY: PRIBOROSTROYENIYE in Russian Vol 25, No 1, Jan 82 (manuscript received 4 Jun 81) pp 57-60

KOPTYAYEV, P. P., Leningrad

[Abstract] In shipboard gyrocompasses with indirect (electromagnetic) correction of torques produced by rotation of the earth and motion of the ship it is possible to eliminate latitude and speed errors in the instrument readings by application of appropriate compensating torques. The torque to be applied to the horizontal gimbal shaft is

$$M_x = H(\omega \sin\varphi + \frac{v \sin K_0 \tan\varphi}{R})$$

and the torque to be applied to the vertical wheel shaft is $M_z = \frac{H}{R} v \cos K_0$

(H- angular momentum of gyroscope, ω- angular velocity of earth, $\varphi$ - geographical latitude of ship's location, v- linear speed of ship, $K_0$- course angle of ship). Input of imprecise data on the ship's latitude, speed and course will result in imperfect compensation. The compensation errors also depend on the inclination and the declination of the gyrocompass as well as on its damping characteristics. Here the effects of input errors $\Delta\varphi$, $\Delta v$ and $\Delta K_0$ on the compensation errors are evaluated for a ship moving at constant speed and course, with its latitude also assumed to be constant within a sufficiently short period of time and with any errors occurring in the computer and in the torque transducers disregarded. Calculations are made on the basis of truncated equations of motion for the gyrocompass. The results also yield the travel of the gyrocompass to a new position of equilibrium and the time to reach it on the basis of erroneous input data. Any ship acceleration alters the initial conditions and thus also the gyrocompass travel time. The article was recommended by the Chair of Shipboard Control Instruments. References 4 Russian.
[186-2415]

UDC 531.383

# ACCURACY OF GYRO STABILIZER DURING RANDOM VIBRATIONS OF PLATFORM

Leningrad IZVESTIYA VYSSHIKH UCHEBNYKH ZAVEDENIY: PRIBOROSTROYENIYE
in Russian Vol 25, No 1, Jan 82 (manuscript received 9 Feb 81) pp 51-57

LESTEV, A. M. and ROMANOVA, A. V., Leningrad Institute of Aviation Instrument Design

[Abstract] The accuracy of a gyro stabilizer under random perturbations due to platform vibrations is estimated on the basis of nonlinear differential equations describing its motion in an instrument that includes a gyroscope mounted in two gimbals, a precession-angle transducer and a stabilizer motor with reducing gears. The elastic compliance of the structural components is disregarded and zero clearance is assumed in the gears, but the dry friction torque in the gimbal bearings is taken into account. This system of three equations is solved by a method of successive approximations, with the probabilistic characteristics of gimbal rotation angle and stabilizer angle error calculated by the method of statistical linearization. The stabilizer accuracy is then estimated from the dispersion of its error and the mathematical expectation of the angular drift velocity. The article was recommended by the Chair of Theoretical Mechanics. Figure 1, references 6 Russian.
[186-2415]

UDC 533.6.011:534.222.2

# EXAMPLE OF SOLVING TRANSONIC EQUATIONS FOR SHOCKLESS FLOW AROUND SYMMETRIC PROFILE

Moscow PRIKLADNAYA MATEMATIKA I MEKHANIKA in Russian Vol 46, No 1, Jan-Feb 82 (manuscript received 22 Oct 80) pp 159-162

IVANOV, V. A. and CHERNOV, I. A., Saratov

[Abstract] A parametric method is developed for solving transonic Karman-Falkovich equations. The nozzel solution is generalized to the case of flows that are asymmetric relative to the nozzle axis. A procedure is demonstrated for conversion from this solution to the example of flow around a profile discussed by Tomotika and Tamada [QUARTERLY OF APPLIED MATHEMATICS, Vol 8, No 2, 1951, p 127]. In this way the authors find the real and imaginary parts of the complex-valued function that describes this flow. The solution depends on three constants that determine profile dimensions (chord length and maximum thickness) and the velocity of flow at infinity. The condition of shockless flow is determined by numerical analysis, and the continuous velocity field is constructed under conditions close to the limiting state. The construction of flow patterns in cases where the shockless condition is violated shows that a convolution of three sheets arises with vertex in the supersonic zone. This confirms the conclusion that in the typical case of flow around a profile the shock wave arises within the zone rather than on the sonic line. Figures 3, references 5: 2 Russian, 3 Western.
[200-6610]

UDC 539.3

## STABILITY OF ANISOTROPIC CYLINDRICAL SANDWICH SHELLS

Kiev DOKLADY AKADEMII NAUK UKRAINSKOY SSR, SERIYA A: FIZIKO-MATEMATICHESKIYE I TEKHNICHESKIYE NAUKI in Russian No 2, Feb 82 (manuscript received 17 Apr 81) pp 26-29

BABICH, I. Yu. and DERIGLAZOV, L. V., Institute of Mechanics, UkSSR Academy of Sciences

[Abstract] The stability under axial compression of a cylindrical sandwich shell with a transversely-isotropic bonding filler in the subcritical state between two thin orthotropic load-carrying layers is analyzed on the basis of the Kirchhoff-Love hypothesis for the outside layers and the linearized theory of elastic stability for the filler. The corresponding equations of stability for a shallow shell with the appropriate conditions of contact between layers are solved in displacements. The resulting system of algebraic equations is solved numerically for the critical load, this critical load being higher than for two unbonded coaxial shells. Article presented by Academician A. N. Guz', UkSSR Academy of Sciences. Table 1, references 5 Russian.
[211-2415]

UDC 531.38

## STABILIZATION OF UNBALANCED ROTOR ON FLEXIBLE SHAFT BY MEANS OF EXTERNAL FRICTION

Moscow VESTNIK MOSKOVSKOGO UNIVERSITETA, SERIYA 1: MATEMATIKA, MEKHANIKA in Russian No 2, Mar-Apr 82 (manuscript received 6 Apr 81) pp 102-106

ZHESTKOV, I. G.

[Abstract] Steady motion of a rotor eccentrically mounted on a flexible shaft has been shown to become destabilized by internal friction (N. G. Chetayev) and by interaction with an external medium distributed over

the surface (P. L. Kapitsa). Here the feasibility of stabilizing the motion of such a rotor is considered, namely by means of external friction proportional to the velocity squared of the rotor center. The analysis is based on calculating the kinetic energy of the rotor and the force function of elastic action, for a rotor in plane-parallel motion with a force couple applied so that the angular velocity of the rotor axis (line joining the shaft bearings) remains constant. The stability regions are determined from the characteristic equation with a third-order determinant, according to the Lienard-Chipard modification of the Hurwitz criterion (first $b' \neq 0$, $a' = c' = 0$, then $b' \neq 0$, $a'$ and $c'$ small, finally $b' \neq 0$, $a' \neq 0$, $c' \neq 0$). Specific regions of asymptotic stability are determined numerically. Figures 3, references 5 Russian.
[214-2415]

UDC 624.04:621.396.91/92

DEFORMED STATE OF HOUSING OF REFLECTOR ANTENNA FOR RT-70 RADIO TELESCOPE UNDER ITS OWN WEIGHT

Baku IZVESTIYA AKADEMII NAUK AZERBAYDZHANSKOY SSR: SERIYA FIZIKO-MATEMATICHESKIKH I TEKHNICHESKIKH NAUK in Russian Vol 2, No 6, Nov-Dec 81 (manuscript received 3 Dec 80) pp 116-123

MAMEDOV, U. V., GAKHRAMANOV, K. I., GASANOV, E. E. and RASULOV, M. B., Institute of Mathematics and Mechanics, AzSSR Academy of Sciences

[Abstract] The finite element method is used for analyzing the state of stress and strain under the weight of a housing that carries the main RT-70 (D-70 m) reflector of a radio telescope antenna. The material is assumed to be linearly elastic, subject to Hooke's law. Calculations in local and global cartesian coordinate systems are based on beam equations for tubular elements and the stiffness matrix, from which equations of equilibrium are derived for the nodal points in the reflector. It is important to number the nodes consecutively so that the differences between numbers of neighboring nodes be as small as possible. Displacements of nodes have been determined on this basis for the appropriate boundary conditions in terms of velocity constraints at fixed and floating nodes respectively. The results agree with practical experience. Figures 4, table 1, references 3 Russian.
[212-2415]

UDC 539.374

DYNAMIC STABILITY OF CYLINDRICAL SHELL MADE OF MATERIAL WITH DIFFERENT MODULI OF ELASTICITY IN TENSION AND COMPRESSION

Baku IZVESTIYA AKADEMII NAUK AZERBAYDZHANSKOY SSR: SERIYA FIZIKO-MATEMATICHESKIKH I TEKHNICHESKIKH NAUK in Russian Vol 2, No 6, Nov-Dec 81 (manuscript received 26 Feb 81) pp 44-48

GADZHIYEV, V. D. and SHAMIYEV, T. M., Institute of Mathematics and Mechanics, AzSSR Academy of Sciences

[Abstract] The problem of dynamic stability under a suddenly applied constant load is solved for a circular cylindrical shell made of a material with different moduli of elasticity and Poisson ratios in tension and compression, resting on hinge supports at both ends that allow free axial movement. The critical parameters are calculated from the system of equations of motion in an axisymmetric mode of stability loss and the system of equations relating stresses to strains. The results indicate a change in critical parameters due to the fact that the moduli of elasticity in tension and compression differ. Figures 1, references 7 Russian.
[212-2415]

STABILITY OF SUPERCONDUCTING CYLINDRICAL SHELL IN MAGNETIC FIELD

Yerevan IZVESTIYA AKADEMII NAUK ARMYANSKOY SSR: MEKHANIKA in Russian Vol 34, No 6, Nov-Dec 81 (manuscript received 20 Feb 81) pp 36-47

BAGDASARYAN, G. Ye., Institute of Mechanics, ArSSR Academy of Sciences, and MKRTCHYAN, P. A., Leninakan branch, Yerevan Polytechnic Institute

[Abstract] Motion of a superconducting closed cylindrical shell in a stationary nonuniform magnetic field is analyzed for the purpose of determining the stability limits. The shell is assumed to be made of an isotropic elastic superconductor material and to have uniform thickness, the magnetic field is assumed to be initially uniform with intensity vector normal to the cylinder axis. The equations of motion are derived from the appropriate field equations and Kirchhoff-Love hypothesis for a thin shell referred to a triorthogonal system of coordinates with nondeformable normals. The stability of an infinitely long shell is considered in a magnetic field with perturbations that are not functions of the coordinates so that the cylinder generatrices remain straight lines. The corresponding infinite system of algebraic equations splits into two independent infinite subsystems, one for only even modes and one for only odd modes of vibration. Rapidly converging successive approximations yield the stability limits in terms of critical magnetic field intensity and minimum shell thickness, both interrelated and dependent on the elastic properties of the material. Numerical data are obtained on the basis of this analysis for

eight shell materials (Nb, Pb, V, Ta, Sn, Al, $Nb_3Sn$, $V_3Ga$). Figure 1, tables 2, references 10 Russian.
[213-2415]

PENETRATION OF BODY INTO MEDIUM DURING VIBRATION

Yerevan IZVESTIYA AKADEMII NAUK ARMYANSKOY SSR: MEKHANIKA in Russian Vol 34, No 6, Nov-Dec 81 (manuscript received 10 May 79) pp 12-26

BAGDOYEV, A. G., Institute of Mechanics, ArSSR Academy of Sciences

[Abstract] Penetration of a thin solid of revolution into an elastic medium is considered in the case where penetration begins during a vibration pulse. Although vibration affects the properties of the medium, far away from the body the latter is assumed to remain elastic with the elasticity parameters depending on the vibration frequency. In the first problem the vibration pulse is applied at the surface of the half-space that the medium occupies, at a location that does not change during penetration. This problem is solved on the basis of the Lamb model of a periodically varying vertical force with viscous flow and friction in the medium, also including the presence of a crack propagation front. In the second problem the vibration pulse is applied at the tip of the penetrating body. This problem is solved on the basis of the model of a constant point force moving at the velocity of penetration. Calculations for a hard body falling and sinking into the ground have yielded data on stresses on such a body and resistance of the soil. Calculations for the first problem were made by G. A. Sarkisyan. Figures 2, tables 3, references 10 Russian.
[213-2415]

UDC 551.456:535.5

DAMPING OF AIRBORNE OR SHIPBOARD OPTICAL INSTRUMENTS

Leningrad OPTIKO-MEKHANICHESKAYA PROMYSHLENNOST' in Russian No 1, Jan 82 (manuscript received 14 Jul 80) pp 37-39

BABAYEV, A. A.

[Abstract] Optical instruments are mounted on board ships or aircraft through dampers, to prevent damage or malfunction due to linear and angular vibrations at high frequencies (above 10 Hz). Vertical damping is usually sufficient, inasmuch as it provides also protection against shock (most often in the vertical direction) and some protection against horizontal vibrations. Here damping of an optical instrument with two springs underneath, one on each side of the center of gravity not necessarily at the center, is treated as a problem of forces and motion in the vertical plane

only. From the equations of force balance and motion an expression is derived for the shift of the image in the object plane, this shift being generally excessive. Since the total energy of vibrations is constant, damping of angular vibrations will increase linear vibrations. As the center of gravity of the instrument is displaced from the center, linear perturbations will produce angular vibrations that reduce resolution of the instrument. When the latter includes gyro stabilization, low-frequency as well as high-frequency angular vibrations must be suppressed. A damper with a parallelogram will eliminate the angular degree of freedom. The necessary precision of such a parallelogram depends on resolution of the optical instrument. Figures 4, references 2 Russian.
[184-2415]

UDC 539.385

TWISTING OF CYLINDERS BY BODY FORCES

Kiev PRIKLADNAYA MEKHANIKA in Russian Vol 18, No 4, Apr 82
(manuscript received 25 Feb 80) pp 122-124

AGRANOVICH, Z. S. and DEREVYANKO, N. I., Khar'kov Institute of Structural Engineering

[Abstract] The problem of elastic twisting by body forces is considered for circular cylinders, generally with zero potential, under static and kinematic boundary conditions. This problem is applicable to magnetized cylinders interacting in an external magnetic field. Assuming that the circumferential twisting forces vary along the radius, the solution is obtained in terms of the stress function and, in a more general form, in terms of the displacement function. With the displacements at the cylinder surface stipulated in the form of four boundary conditions, the problem can be split into two problems with the first pair or the second pair of boundary conditions homogeneous. References 6 Russian.
[237-2415]

UDC 539.3

EFFECT OF INITIAL DEFLECTIONS ON NATURAL VIBRATIONS OF FINNED CYLINDRICAL SHELLS

Kiev PRIKLADNAYA MEKHANIKA in Russian Vol 18, No 4, Apr 82
(manuscript received 3 Dec 80) pp 58-63

KUKARINA, A. I., MATSNER, V. I. and SIVAK, E. F., Institute of Mechanics, UkSSR Academy of Sciences, Kiev

[Abstract] Vibrations of nonideal finned cylindrical shells, with initial imperfections (deflections) are analyzed on the basis of experimental data and theoretical considerations. Measurements were made with a GZ-34 audio-frequency oscillator, a U2-6 instrument amplifier, a phase shifter, a miniature piezoelectric transducer, an F5080 frequency meter and chronometer, and an oscillograph. Natural modes and frequencies were determined, with initial deflections of the order of the shell thickness in alternating directions measured at 576 points of a shell. The coefficients of the fitting double trigonometric series were calculated according to a program written in ALGOL-60 for a BESM-4 high-speed computer. The theoretical analysis is based on a Lagrange equation of the second kind, with appropriate double-integral expressions for kinetic and potential energy of a shallow orthotropic shell, with linearization of the equation of strain compatibility, and with deflections expressed in the form of products of space harmonics and a time function or a constant coefficient. This Lagrange equation reduces to a second-order differential equation which is then solved. Typical numerical results indicate that accounting for initial deflections in calculations yields higher natural frequencies and closer agreement with experimental data. Figures 5, references 4 Russian.
[237-2415]

UDC 539.3:534.1

OPTIMUM CONTROL OF NATURAL FREQUENCY OF NONHOMOGENEOUS SHELLS

Kiev PRIKLADNAYA MEKHANIKA in Russian Vol 18, No 4, Apr 82
(manuscript received 23 Jan 81) pp 41-47

KRYS'KO, V. A. and PAVLOV, S. P., Saratov Polytechnic Institute

[Abstract] Optimum design control of natural frequencies is considered in the case of a shallow shell describable by equations of the Timsohenko kind with orthotropic and nonuniform elastic properties, also with shear taken into account. The existence of at least one such control is proved, and a sequence of finite-dimensional problems approximating the problem of optimum control is constructed in Sobolev space $W_2^1(\Omega)$ after the convergence of such a sequence is proved. The theory is then applied to a specific example involving minimization of three variables by a method of adaptive random search. The natural frequencies of a rigidly clamped isotropic rectangular

plate are calculated through solution of the corresponding eigenvalue problem on each optimization step by a method of variational iteration. The number of unknowns is reduced in the course of discretization of the plate thickness profiles. An almost exact solution is found to be attainable for the fundamental frequency of rectangular plates with $h(x,y) = h_1(x)h_2(y)$ (h-thickness). Figure 1, table 1, references 7 Russian.
[237-2415]

UDC 624.074.4:539.37

AXISYMMETRIC DEFORMATION OF NONHOMOGENEOUS FLEXIBLE SHELLS OF REVOLUTION

Kiev PRIKLADNAYA MEKHANIKA in Russian Vol 18, No 4, Apr 82
(manuscript received 21 Nov 79) pp 36-40

KLIMANOV, V. I. and CHUPIN, V. V., Ural Polytechnic Institute, Sverdlovsk

[Abstract] Nonhomogeneous elastic flexible shells of revolution of general form are considered under a stepwise increasing axisymmetric load. The system of first-order differential equations in coordinates of the deformed surface for each loading step and the corresponding overall boundary-value problem of stress and strain are reduced to a series of Cauchy problems and the latter solved by a Runge-Kutta method. The procedure is demonstrated on an elastic system consisting of thin flexible shells, each a stack of an arbitrary number of orthotropic variable-thickness layers. The algorithm has been programmed in FORTRAN for numerical solution on a BESM-6 high-speed computer. The results for a shallow spherical panel and for a thin annular disk under uniform pressure agree closely with those obtained by other authors according to other programs. The procedure is then applied to bending of a thin-walled flexible system consisting of a spherical panel and a cylindrical shell under external pressure. Figures 2, tables 3, references 7 Russian.
[237-2415]

UDC 539.3

STATE OF STRESS OF NONHOMOGENEOUS THICK-WALLED SPHERICAL SHELLS UNDER ASYMMETRIC LOADS

Kiev PRIKLADNAYA MEKHANIKA in Russian Vol 18, No 4, Apr 82
(manuscript received 11 Feb 81) pp 22-28

VASILENKO, A. T., GRIGORENKO, Ya. M. and PANKRATOVA, N. D., Institute of Mechanics, UkSSR Academy of Sciences

[Abstract] The state of stress and strain of thick-walled closed spherical shells under axisymmetric mechanical loads in a temperature field is calculated

for the case of arbitrary nonhomogeneity across the wall thickness. Generally such a shell consists of transversely isotropic layers of uniform thickness, the elastic properties of each being arbitrary functions of the radial coordinate. Here each layer is treated according to the theory of elasticity of a nonhomogeneous anisotropic body. The corresponding equations of equilibrium, strain-displacement relations and Hooke's law are written in spherical coordinates $r,\varphi,\theta$ assuming conditions of rigid contact between layers. These equations are reduced to a system of six equations in functions describing the conditions of layer-to-layer compatibility. The solution is sought in the form of series in spherical functions with associated Legendre polynomials. The algorithm of numerical solution for this class of problems has been programmed for a computer. Here results are shown first for a single-layer isotropic shell under a pressure $p_2^{(1)}\cos\varphi\cos\theta$, its modulus of elasticity varying linearly in the radial direction, and then for a sandwich shell of either symmetric or asymmetric structure under the same load. Figures 2, tables 2, references 8: 7 Russian, 1 Western.
[237-2415]

UDC 626.022.2.001.63

## SELECTION OF BREATHING GAS CONDITIONER SYSTEM FOR DIVING CHAMBERS

Leningrad SUDOSTROYENIYE in Russian No 2, Feb 82 pp 31-32

ZAKHAROV, Yu. V. and NAZARENKO, I. A.

[Abstract] Breathing gas conditioners for diving compression-decompression chambers are selected on the basis of a comparative performance analysis of three variants with condensation-type dehumidifier and three variants with adsorption-type dehumidifier. The exergetic efficiency used as quality criterion depends on both the temperature of the cooling water and the volume flow rate of gas mixture through the dehumidifier. Adsorption-type dehumidifiers with zeolite $CO_2$ adsorbers are more efficient than condensation-type dehumidifiers with $CO_2$ absorbers over almost the entire range of absolute pressure and comfortable relative humidity, they operate most efficiently with heat regeneration. Condensation-type dehumidifiers, used in special cases, operate most efficiently with heat recuperation and at the minimum possible volume flow rate of gas mixture. At outboard water temperatures above 8-10°C and a 40-50% relative humidity of the breathing gas it becomes economical to include a special water cooler. Figures 3. [206-2415]

UDC (678.06:678.744.3):534.286.2

## PRODUCTION AND APPLICATION OF VIBRATION ABSORBING POLYACRYL-VS MATERIAL

Leningrad SUDOSTROYENIYE in Russian No 3, Mar 82 pp 46-48

VOLKOV, R. A., VINOGRADOV, B. D., BELYAYEV, N. P. and KOVALEV, V. A.

[Abstract] Polyacryl-VS is a material for coating up to 10 mm thick hull structures. It absorbs vibration and sound, reducing them by 5-15 dB at low-to-medium frequencies and by 15-25 dB at medium-to-high frequencies over the temperature range from -10 to +50°C. It is a composite consisting of 60 μm thick aluminum laminations alternating with a polymer (polybutyl

methacrylate) binder. The thickness of binder layers is, depending on the material of the protected structure, either 120 μm (for light-weight alloys) or 240 μm (for steel). The binder is produced in three stages: preparing paste of 50% dibenzoyl peroxide in dioctyl sebacate, preparing butyl methacrylate, and mixing both ingredients according to one of two proven formuals. Adding 2,3-dibromopropyl phosphate accelerates the polymerization process, which should not occur earlier than 1-2 hours before aluminum foil is stacked. Stacking of the composite is done on a special machine (USSR Patent disclosure No 680896) consisting of a foil carrying drum with drive, a binder holding vat, a takeup drum with drive, a manipulator with drive, a pinchcock, a foil cutter, a tension regulator and a revolution counter. The composite sheet is degreased and then applied to the surface of a structure according to standard technology, by means of a roller under pressure (0.002-0.008 MPa) with the same binder material serving as adhesive. Safety measures include protection of personnel against butyl methacrylate vapor by providing adequate ventilation and washing facilities. Only limited necessary quantities of binder and solvents should be stored in the work area. The special machine, model PVS-1M, is more efficient and economical as well as safer than equipment used for producing other coating materials. Figures 2, tables 3.
[205-2415]

UDC 621.822.9

CAPACITY OF SLIDING BEARINGS IN HELIUM ATMOSPHERE

Moscow ENERGOMASHINOSTROYENIYE in Russian No 3, Mar 82 pp 36-39

BOGOYAVLENSKIY, R. G., candidate of technical sciences, NIKIFOROV, Yu. D., candidate of technical sciences, MAKAROV, Yu. V., candidate of technical sciences, YERMAKOV, A. T., candidate of technical sciences, and ANAPOL'SKIY, A. B., engineer

[Abstract] Friction and wear characteristics of self-lubricating coatings $MoS_2$, $MoS_2$ + (20-25) vol.% Pb, $MoS_2$ + ZnS and solid lubricants $MoS_2$ + PbS, $MoS_2$ + PbS + $(FeMo)S_2$ in various combinations of rubbing pairs were studied in an atmosphere of helium used as reactor coolant at approximately 300°C. First all pairs were tested at a sliding velocity of 0.5 m/s under a specific load of 0.6 MPa, then the best pairs were tested at sliding velocities of 0.05, 0.5 and 0.7 m/s under a specific load of 0.3 MPa. In addition, these materials were also paired against Kh18N10T steel and S-820 pseudoalloy (porous N18K9M3T martensitic aging steel impregnated with molten Pb + 25 vol.% Cu). Furthermore, radial bearing pairs sleeve-on-shaft and radial-thrust bearing pairs sleeve-on-sleeve (200 rpm) were life tested in a UTT-1 stand. The results indicate that $MoS_2$ and $MoS_2$ + Pb layers of a combined thickness over 100 μm will impart an adequate performance margin to sliding bearings for operation in atomic plants with helium. Figures 2, tables 4, references 10: 9 Russian, 1 Western.
[208-2415]

UDC (669.018:621.1):620.17

# COMPLEX STUDIES OF POWER EQUIPMENT MATERIALS AND COMPONENTS IN HEAVY-CAPACITY TESTING MACHINES

Moscow ENERGOMASHINOSTROYENIYE in Russian No 3, Mar 82 pp 18-20

MARKOV, N. M., doctor of technical sciences, general director of scientific-industrial association of Central Boiler and Turbine Institute,
POSTNOV, L. M., doctor of technical sciences, and KIZIMA, V. A., engineer

[Abstract] A complex of heavy-capacity testing machines has been developed and built during the period of the 10th Five-Year Plan for materials and components of water-moderated water-cooled reactors in AES's. The largest of them is the ZZ-8000 hydraulic machine with a maximum capacity of 80,000 kN for testing the resistance to brittle fracture of items up to 250 mm thick, up to 1200 mm wide and 1200-4000 mm long. It has been developed jointly by the scientific-industrial association at Central Boiler and Turbine Institute and experts from Czechoslovakia. Another one is the "Sigma-2" hydraulic machine with a maximum capacity of 15,000 kN for testing the short-cycle fatigue strength of materials and dummy reactor components up to 120 mm thick, up to 650 mm wide and 1500-2500 mm long, or cylinders up to 120 mm in diameter. These machines were used to test components of VVER-1000 reactors and their materials, specifically alloy steels 38KhN3MFA and 15Kh2NMFA (also 12Kh2MFA used in VVER-440 reactors). Critical stresses and safe operating temperatures for these components have been established on the basis of tests performed in these machines. Figures 4.
[208-2415]

UDC 533.15

# INFLUENCE OF PRESSURE ON HYDROGEN PENETRATION THROUGH OXIDIZED STEELS AND ALLOYS AT 685°C

Moscow ATOMNAYA ENERGIYA in Russian Vol 52, No 2, Feb 82
(manuscript received 5 May 80, after revision 20 Jul 81) pp 128-129

BORISOVSKIY, A. F. and POSOBILO, T. S.

[Abstract] Hydrogen permeability of oxide films was studied on tubular specimens with wall thickness of 1 mm. Hydrogen inside the specimens was held at a pressure of from $2.65 \cdot 10^3$ to $9.3 \cdot 10^4$ Pa. Penetrability as a function of pressure was determined on specimens of 2Kh13, 12Kh18N10T, OKh16N15M3B, 1Kh13M2FB, 1Kh13F2M2 and OKh18Yu2 grade steels, and KhN40B alloy oxidized in water vapor or atmospheric air. The experiments were done at 685 $\pm$ 5°C. It was found that the permeability of the oxidized specimen as a function of hydrogen pressure p at constant temperature and without back pressure is given by $\Phi \sim p^n$. For the investigated steels with outer oxide coatings the

on n are equal to 0.5 and 1.0. For some steels, n depended on the composition of the ambient atmosphere: for hydrogen diffusion through a specimen of 0Kh16N15M3B into air, n = 0.5, and into water vapor, n = 1.0; the opposite is true for 2Kh13 and 1Kh13M2FB with n = 1 for diffusion into air, and n = 0.5 for water vapor. The ambient medium had no effect on the way that permeability depends on hydrogen pressure for 1Kh13F2M2 steel and KhN40B, which both had n = 1. For 1Kh13F2M2, n = 1 for diffusion into water vapor at 500, 590 and 685°C. The value of n = 0.5 is taken as evidence of hydrogen diffusion in the atomic state, while n = 1 corresponds to diffusion of molecular hydrogen. Figures 2, references 2 Western.
[202-6610]

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